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# Influence of sand on strength characteristics of cohesive Soil for using as Subgrade of road

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**Abstract**

For safe and cost effective construction of pavement, subgrade plays an important role and such layer is constructed generally with suitable fill materials collected and transported from the borrow pits nearby to the proposed construction site, resulting in creation of low lying areas as well as loss of top productive layer of soil. Usually cohesive soil is one type of the weak soil which is a typical example of available soils in flood-plain of West Bengal, which is an extension of Indo-Gangetic plane, used for construction of subgrade of road. Further sand is a naturally occurring granular material composed of finely divided rock and mineral particles and generally it is used as a filler material because of its high load bearing capacity particularly in confined condition. So for improving the different properties of cohesive soil, an exhaustive study has been undertaken by the author to test possible uses of various types of sand with varying proportions ranging from 5% to 15% as admixture to cohesive soil and to evaluate their different properties e.g. plastic properties, compaction properties and strength properties in terms CBR of the mixtures. Experimental results indicated the better improvement in the compaction characteristics as well as in the CBR for addition of fine sand upto 15% with the soil and identified as cost effective mix proportion for the construction of subgrade of flexible pavement.



Keywords: Subgrade, Cohesive soil, Sand, MDD, OMC, CBR

## Introduction

The prime requirement for the development of any country is the good communication systems and such system can be developed by constructing sufficient infrastructure of roads, tunnels, bridges and other civil engineering works. In recent years, a rapid growth is occurred in the transportation sectors in India due to undertake various schemes like Pradhan Mantri Gram Sadak Yojana, Golden Quadrilateral scheme etc by the Government of India. As the performance of a constructed road essentially depends on the various parameters e.g. the quality of the subgrade material, the materials used in different layers of the pavement and the traffic, so

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selection of suitable subgrade materials with better quality becomes essential for getting the better performance with longevity of the constructed roads. Since India has a vast area of soft soils along its long coast which are highly compressible with low bearing capacity. So it is essential to improve the subgrade materials for reducing the construction cost of the pavements their by reducing their layer thickness. A large number of investigators made their investigation to improve the characteristics of such types of low strength soils not only by adding different alternative materials but also various chemicals (Bhasin et al. 1985; Richardson, 1996; Ghosh and Subbarao, 2007; Sharma et al. 2013). Further sand is non-plastic granular material obtained from the natural sources have the high bearing capacity in confined condition. In order to improve the characteristics of the weak soil, different types of sand may be used, which changes the grain size configuration of such soils. The main objectives of the present study are to evaluate the different improve characteristics of the alluvial soils with addition of sand and their cost effective mix proportion.

## Materials Used

*Soils:* In this study, two types of alluvial soils have been collected from shallow depth of two different places namely BESU campus, Howrah and Rajarhat in the alluvial flood plain of West Bengal and identified as Soil-I, Soil-II respectively. Evaluated grain size distribution of same are furnished in the figure 1and other properties in table 1. Based on liquid limit and plasticity index, soil-I and soil-II may be classified as CI and CH respectively.

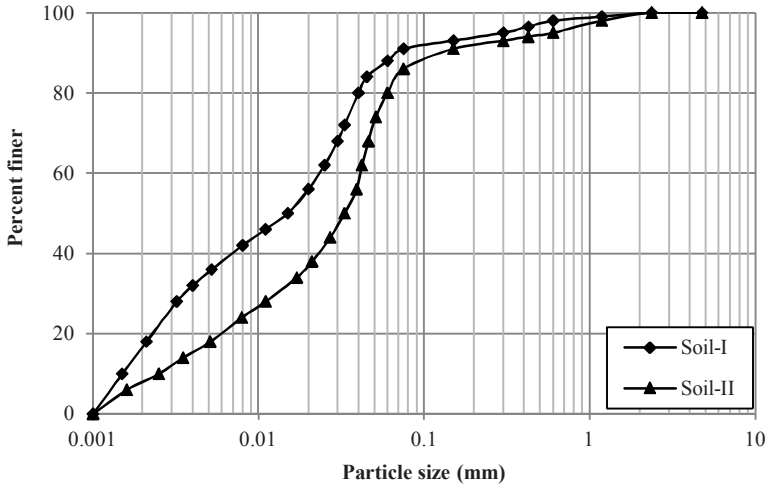


Fig.1 Particle size distribution curves for Soil-I and Soil-II[1]

*Sands:* Three types of sands were chosen for the purpose of testing. These sands may be classified as fine silver sand obtained from river bed of Hooghly at Howrah and the other two were medium brown sand and coarse brown sand purchased from the local market. The sizes of the particles of these three types of sand are reported in figure 2. These are non-plastic in behavior. The uniformity coefficient of fine silver sand, medium sand and coarse sand is 4.71, 3.06 and 1.80 respectively and the coefficient of curvature is 0.99, 0.91 and 1.84 respectively. The specific gravity of the said materials is 2.57, 2.50 and 2.41respectively.

Table 1: Evaluated properties of the soils

| Sl. No | Properties | Soil-I | Soil-II |
|---|---|---|---|
| 1 | Light compaction- | | |
| | Proctor's Maximum dry density (kN/m$^3$) | 15.70 | 18.80 |
| | Optimum moisture content (%) | 18.52 | 17.93 |
| 2 | Specific gravity | 2.63 | 2.58 |
| 3 | CBR- | | |
| | Unsoaked (%) | 4.65 | 5.35 |
| | Soaked (%) | 2.45 | 2.95 |
| 4. | Plastic properties- | | |
| | LL (%) | 40.00 | 63.52 |
| | PL (%) | 24.90 | 26.84 |
| | PI (%) | 15.10 | 36.68 |

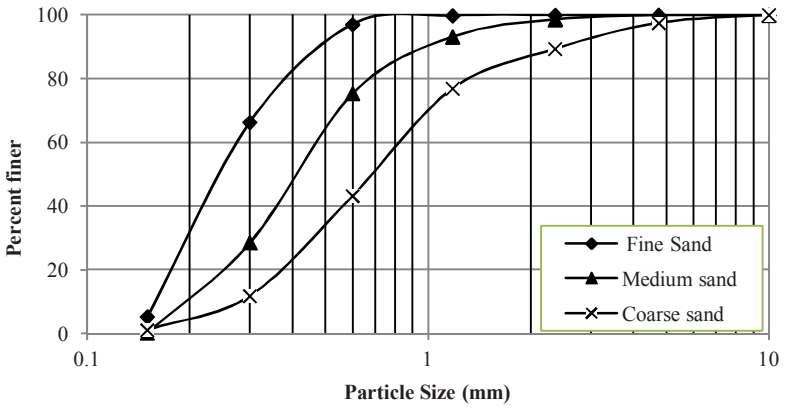


Fig.2 Particle size distribution curves for Fine, Medium and Coarse sand

## Experimental Methods

In this study, for evaluating the quantitative information about the mixed soil, various types of sand were mixed with the two different types of soil samples and different characteristics e.g. plastic properties, compaction characteristics and strength in term of California bearing ratio (CBR) in unsoaked condition at optimum moisture content were determined as per relevant Indian standard code of practice. The quantity of sand 0%, 5%, 10% and 15% are mixed with fine, medium and coarse sand by weight of soil sample to obtain soil mixes I and II.

## Experimental Results and Discussions

*Plasticity properties*

The effect of adding coarse, medium and fine sand in varying percentage from 0% to 15% as mentioned in table 2, on the plasticity characteristics e.g. Liquid limits (LL), Plastic limits (PL) and Plasticity index (PI) of the soils-I and II are given in table 2.

Table 2: LL, PL and PI of Soils and Sand mixed Soils

| Type of Soil | Type of Sand Mixed | % of Sand | LL (%) | PL (%) | PI (%) |
|---|---|---|---|---|---|
| Soil-I | Fine Sand | 0 | 40.00 | 24.90 | 15.10 |
| | | 5 | 35.85 | 24.50 | 11.35 |
| | | 10 | 35.15 | 24.35 | 10.80 |
| | | 15 | 34.80 | 24.10 | 10.70 |
| | Medium Sand | 0 | 40.00 | 24.90 | 15.10 |
| | | 5 | 36.15 | 24.35 | 11.80 |
| | | 10 | 36.00 | 24.30 | 11.70 |
| | | 15 | 35.60 | 24.05 | 11.55 |
| | Coarse Sand | 0 | 40.00 | 24.90 | 15.10 |
| | | 5 | 36.25 | 24.30 | 11.95 |
| | | 10 | 36.05 | 25.14 | 10.91 |
| | | 15 | 35.85 | 24.65 | 11.20 |
| Soil-II | Fine Sand | 0 | 63.52 | 26.84 | 36.68 |
| | | 5 | 59.15 | 26.30 | 32.85 |
| | | 10 | 58.95 | 26.40 | 32.55 |
| | | 15 | 58.60 | 25.91 | 32.69 |
| | Medium Sand | 0 | 63.52 | 26.84 | 36.68 |
| | | 5 | 59.80 | 27.00 | 32.80 |
| | | 10 | 59.50 | 26.88 | 32.62 |
| | | 15 | 59.10 | 26.60 | 32.50 |
| | Coarse Sand | 0 | 63.52 | 26.84 | 36.68 |
| | | 5 | 59.95 | 26.90 | 33.05 |
| | | 10 | 59.40 | 26.40 | 33.00 |
| | | 15 | 59.10 | 26.85 | 32.25 |

Evaluated results as shown in table 2, it is observed that LL, PL and PI of soil-I are 40.00%, 24.90% and 15.10% respectively and for soil-II are 63.52%, 26.84% and 32.50% respectively. However in all the cases with addition of sand, Liquid limit decreases at a fast rate initially and then decreases at a very slow rate and become nearly constant value with further addition of sands. Such value remains as 34.80%, 35.60% and 35.85% for addition of 15% of fine, medium and coarse sand with soil-I respectively and 58.60%, 59.10% and 59.10% with soil-II respectively. But Plastic limit does not change appreciably and remain as more or less constant, resulting

the variation of Plasticity Index followed same pattern of variation as that of Liquid Limit. Similar observation was made from the results of investigation performed by Ravi Shankar (2012).

*Compaction characteristics*

To make a visual comparison of the effects of mixing different types of sands e.g. fine, medium and course in varying proportions in the soils on maximum dry density (MDD) and optimum moisture content (OMC), experimental results are plotted in the figures-3 and 4 in terms of maximum dry density (MDD) and figures- 5 and 6 in terms of optimum moisture content (OMC) for varying percentages sands.

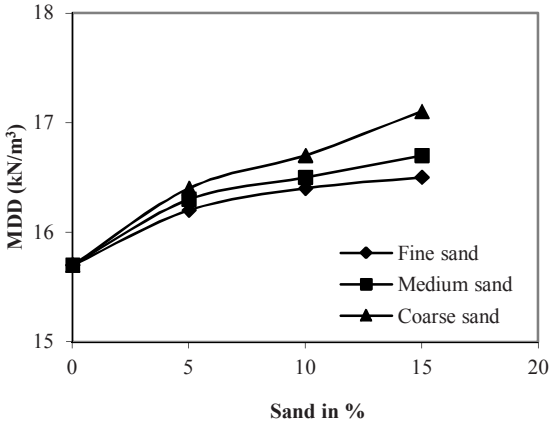


Fig. 3 Variation of MDD of soil-I mixed with varying percentage of different sand

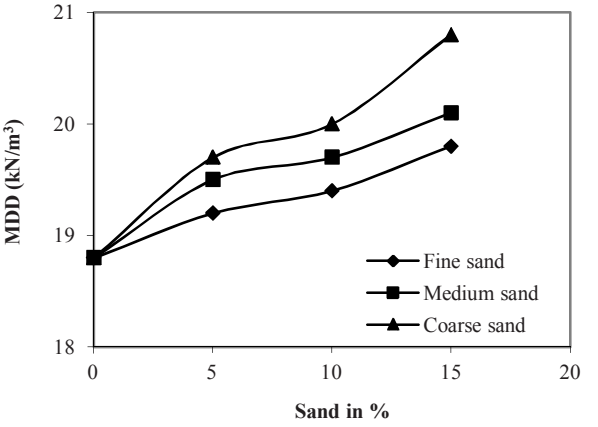


Fig. 4 Variation of MDD of soil-II mixed with varying percentage of different sand

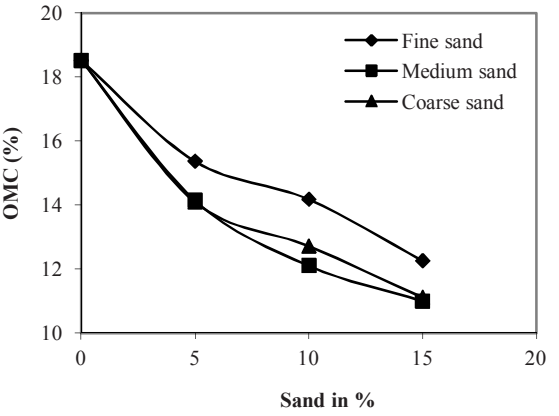


Fig. 5 Variation of OMC of soil-I mixed with varying percentage of different sand

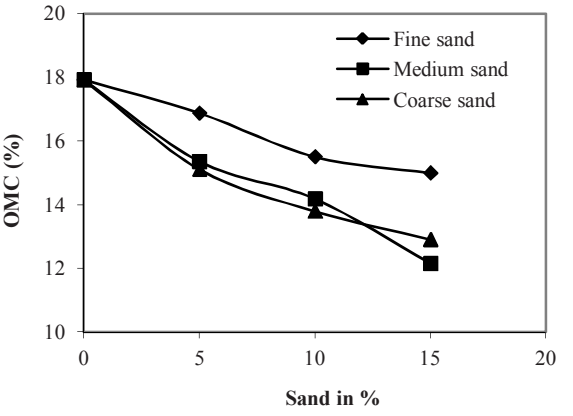


Fig. 6 Variation of OMC of soil-II mixed with varying percentage of different sand

From the figures 3 and 4, it is observed that when soil-I mixed with fine sand in higher percentages, MDD increases from 15.70 kN/m$^3$ to 16.50 kN/m$^3$. But for same soil when medium sand in mixed in increasing

percentages (with in test limit), the MDD increase from 15.70 kN/m$^3$ to 16.70 kN/m$^3$. In case of mixing coarse sand, the effect on MDD is more or less similar to that for medium sand. Similar observations are made for Soil-II, though increase in the values of MDD values is more noticeable for the soil collected from Rajarhat area having CH group of soil.

Effects of mixing sand in various percentages on OMC of the soils-I and II are shown in the figures 5 and 6 respectively. It is observed that addition of all types of sand in increasing percentage decreases gradually the values of OMC compared to that of the tested soils and this value reduces gradually from 18.52% to 11.00% for Soil-I and from 18.52% to 12.15% for Soil-II for addition of 15% medium grained sand. This is the indication of lesser demand of water for achieving the desired compaction in the field. Similar observations on compaction properties of soil blended with sand were made by Ravi Shankar (2012) both standard proctor test and modified proctor test on Lithomergic soil.

*Strength characteristics*

To determine the strength characteristics of soils in terms of CBR with addition of sand in varying proportions, CBR tests in unsoaked condition were performed at OMC as per the guideline of IS 2720 (Part XVI) and the result is furnished in the figures 7 and 8 for soil-I and Soil-II respectively.

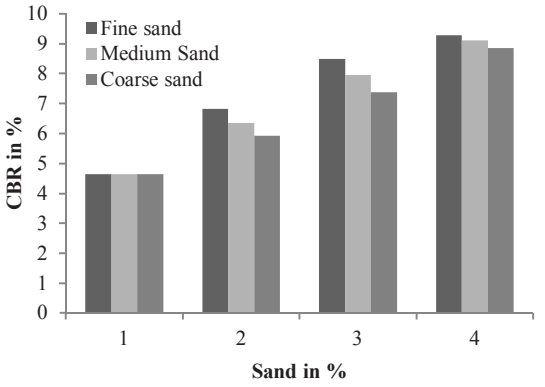


Fig. 7 Variation of CBR (Unsoaked) of soil-I mixed with varying percentage of different sand

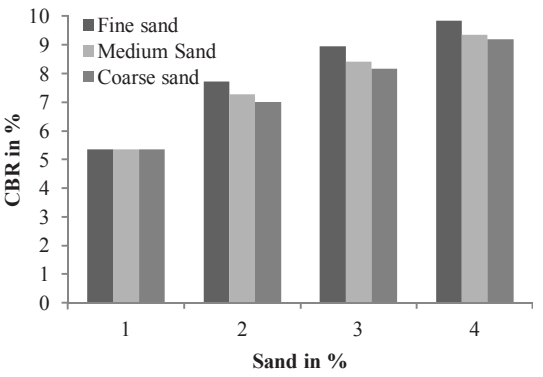


Fig. 8 Variation of CBR (Unsoaked) of soil-II mixed with varying percentage of different sand

From the figures 7 and 8, it is obvious that CBR value of the tested soil-I and II in unsoaked condition is 4.65% and 5.35% respectively. But for mixing of various types of sand with their increasing quantity, this value has been improved to a much higher values in both the cases. Significant observation is made for the addition of fine sand with both types of soil compare to that of other two types of sand e.g. medium and coarse sand. The CBR value increases from 4.65% to 9.28% and 5.35% to 9.84% for addition of fine sand upto 15% with the virgin soil-I and II respectively. This change may be occurred due to achieving the better grain size distribution of the mixed soil sample. Similar trend also reported by Ravi Shankar (2012) in the CBR values of Lithomergic soil with addition of sand.

## Conclusions

From the experimental results, the following conclusions may be drawn-

I) The Liquid Limit of all the alluvial soils indicated decrease in values with initial addition of any sand, however further increases in greater proportion, a small reduction is observed of such values. But Plastic Limit of all the soils does not show any significant change with increase of sand percentages within the range of the test. As results Plasticity Index shows a lesser values with increase of sand content as Liquid Limit.

II) In compaction characteristics, MDD values of all the two types of alluvial soils shows a significant increases in the values of MDD with addition of any of the three types of sands used. Conversely OMC values all such alluvial soils indicated a gradual decreased with increasing in the values of sand percentages added, irrespective of the sand used. This is the indication of lesser demand of water for achieving the desired density in the field.

III) In strength properties, the CBR values are indicated a very large amount with addition of any of the sand used in the test. However better result is observed for mixing of fine sand, and such value in unsoaked condition become nearly doubled for addition of fine sand upto 15% compare to that of tested soils and may be identified as cost effective mix proportion because for reducing the thickness of different layers of flexible pavement due to better improvement in the CBR value.

## Acknowledgements

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